

## PROPERTY ANALYSIS OF BULLET PROOF VEST FABRICATION

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### ABSTRACT

*Bulletproof Vests Are Contemporary Light Armor Explicitly Fabricated To Protect The Wearer's Vital Organs From Injury Triggered By Firearm Projectiles. It Substantially Absorbs And Diminishes The Impact Of Projectile Bullets And Insignificant Fragments From Explosives, By Preventing The Penetration Internally Through The Wearer's Body. Bulletproof Clothing Is Fabricated By Layering Woven Or Laminated Fibers, With Ballistic Plates Of Metal, Polythene Plates Or Ceramic Interlaced Into It.*

*Substantially Immense Number Of Countries Acquires Bulletproof Vests For Their Armed Forces. The Industry Is Still Exploring With Their Emphasis On Improvement Of Materials Used In Bulletproof Clothing. To Protect The Wearer From Blade Attacks Along With Firearms Exploration Has Been Carried Out In Armor Performance. Furthermore, Expanding Focus On Wars Is Fostering Up The Demands Of Bulletproof Clothing Universally. This Paper Deals With The Properties Of Fibre And Projectile Related Parameters For The Fabrication Of Bullet Proof Vest With Sophisticated Technology.*

**KEYWORDS:** Bullet Proof Vest, Projectiles, Fibre, Kevlar & Woven

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### INTRODUCTION

In the advancement of scientific technology, multitudinous researches have been articulated in diverse countries for the advancement of bullet proof vests. A bullet proof vest is protective clothing fabricated from divergent materials which comprehend the impact of projectiles emerge from weapons and explosive fragments. It could be formulated from steel, ceramics, polyethylene and Kevlar. Bullet proof vests not only deflect bullets furthermore catch the bullet and spread its force over a larger portion of the body.

### Threat Classification based on Kinetic Energy Density (KED)

The various Threat classification is shown in the Table: 1

Table 1

Threat	Velocity (m/s)	KED (J/square millimeter)	Armors used
Knife	10	17(Blunt) 210(Sharp)	Special Textiles or plates
Hand gun	450	16 (Initial) 4(Final)	Textiles
Assault Rifle Bullet (AK 47)	720	45	Composites
High Velocity Bullet (SA 80)	940	75	Ceramic

## **Types of Bullet Proof Vests**

Presently two types of bulletproof vests are available.

- Hard Bullet proof vests
- Soft Bullet proof vests

### **Hard Bullet Proof Vests**

Metal or ceramic fibres are fabricated internally along the fabric structure in this type of vests. These vests are hard and heavy consequently used for military bureaucrats in the high risk regions further more imparts protection against high velocity projectiles.

### **Soft Bullet Proof Vests**

In soft Bullet proof vest, multilayered woven or laminated fabric structure is employed. As a result they are lighter and flexible. It is employed in customary wear of police officers and security personnel. It offers protection against low velocity projectiles. Almost 20 to 30 layers of fabric are requisite for adequate protection which acts as the vital drawback of these vests. Finally they develop toward inflexible in nature.

### **Factors Affecting Impact Performance**

The factors which are influencing impact performances are

- Fiber and Fabric related parameters
- Projectile related parameters

### **Fiber and Fabric related Parameters**

#### **Fibers used**

Prominently fiber used for bullet proof vests include,

- Para Aramid Fibers – Kevlar (Dupont)
- Ultra High Molecular Weight Polyethylene (UHMWPE) – Dyneema, Spectra

Other fibers are,

- Polyphenylene Benzobizoxazole (PBO)
- Zylon (Toyobo)
- Inorganic fibers – Carbon and glass

### **Fiber Property**

Following properties are important for the manufacturing of bullet proof vests.

- High Modulus
- High Tensile Strength
- Low density

- Low elongation
- Good resilience
- Low moisture retention
- High Thermal Stability
- High Limiting Oxygen
- Stability in Extreme Conditions

### **Yarn Twist**

Low Twist level is recommended, as increase in yarn twist results in,

- Reduction in yarn strength
- Reduction in Breaking Elongation
- Reduction of modulus

Necessitating the passage of projectile into the fabric.

### **Weave**

Subsequent weaves are appropriate for 2D structures of fabric. Plain, Basket, Twill and satin weaves are employed. Angle Interlock, Warp Interlock and Orthogonal Weaves are exerted for 3D structures.

### **Fabric Cover Factor**

Cover Factor ought to range from 0.6 – 0.95. When it is higher than 0.95, jamming condition occurs. Yarn damage transpires owing to weaving technique. If cover factor is less than 0.6, loosely woven fabrics are resultant, which entails easy penetration for projectiles.

### **Crimp**

Crimp level ought to be as low as possible. As the crimp level increases, the projectile resistance is decreased.

### **Friction**

Friction plays a significant part in ballistic protection. Coefficient of friction ought to be 0.2. If friction level is elevated, local stress concentration will be high. Consequently, depreciation occurs in yarn breakage and energy absorption. Accordingly projectiles can penetrate effortlessly.

### **Number of Layers**

The Ballistic limit (m/s) increases with the number of fabric layers.

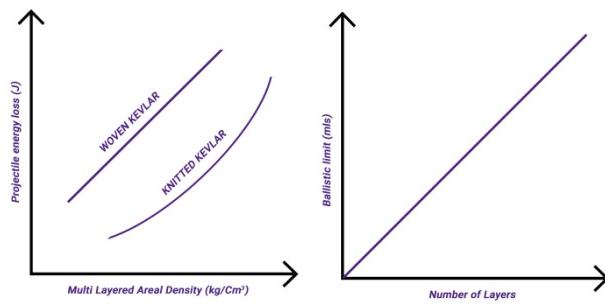


Figure 1

Figure 2

### Energy Absorption of Fabrics

Knitted fabric offers a loss of projectile energy while woven Kevlar imparts the highest energy absorption owing to its high modulus and high strength value.

### Projectile Related Property

**Projectile Geometry:** There are diverse forms of projectiles. Based on the tip dimensions the geometric shape projectors exist inclusive of Hemispherical, Conical, fragmented and flat. Whereas the conical pointed bullet causes severe deface.

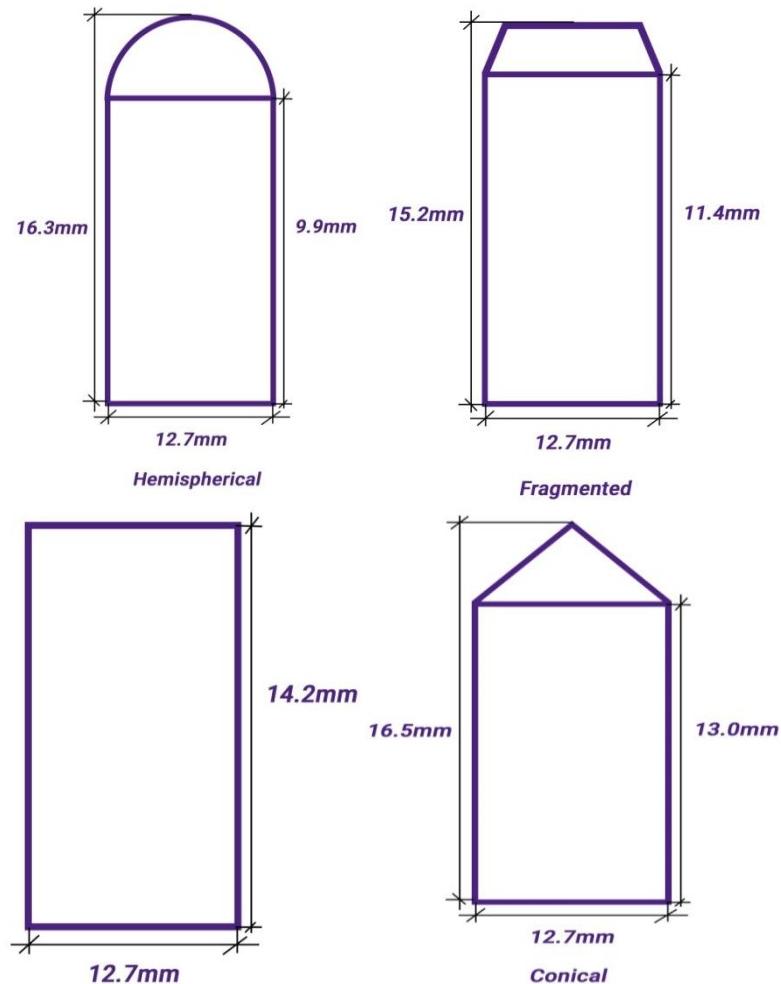


Figure 3

## **Impact Angle**

Angle of impact is more significant in view of the fact that low angle of impact induce sliding. On the other hand, projectile penetrates if the angle of impact is 90 degree, accordingly no transpires. In bullet proof vests, merely peripheral area is acquainted.

## **Future Work**

Bullet proof vests could extensively be procreated for the advancement and progression of defense. The primary impediment of the bullet proof vests is its bulkiness. Hard bullet proof vests are fabricated with metal or ceramic plates impregnated into fabric structure which obstruct the body movements. Soft bullet proof vests employ 20 – 30 layers for sufficient protection. Consequently, further they become inflexible in nature. Accordingly, to diminish the bulkiness of the soft bullet proof vests, varied researches are under progress. Several research works is being formulated to employ resin fabric composites, application of 3D Woven fabrics, Nonwoven fabrics with Cushion Layers, Incorporation of CNTs and Nano fibers in Fabrics for bullet proof vest fabrication.

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